National Aeronautics and Space Administration

How HRP Research Results Contribute to Human Space Exploration Risk Mitigation

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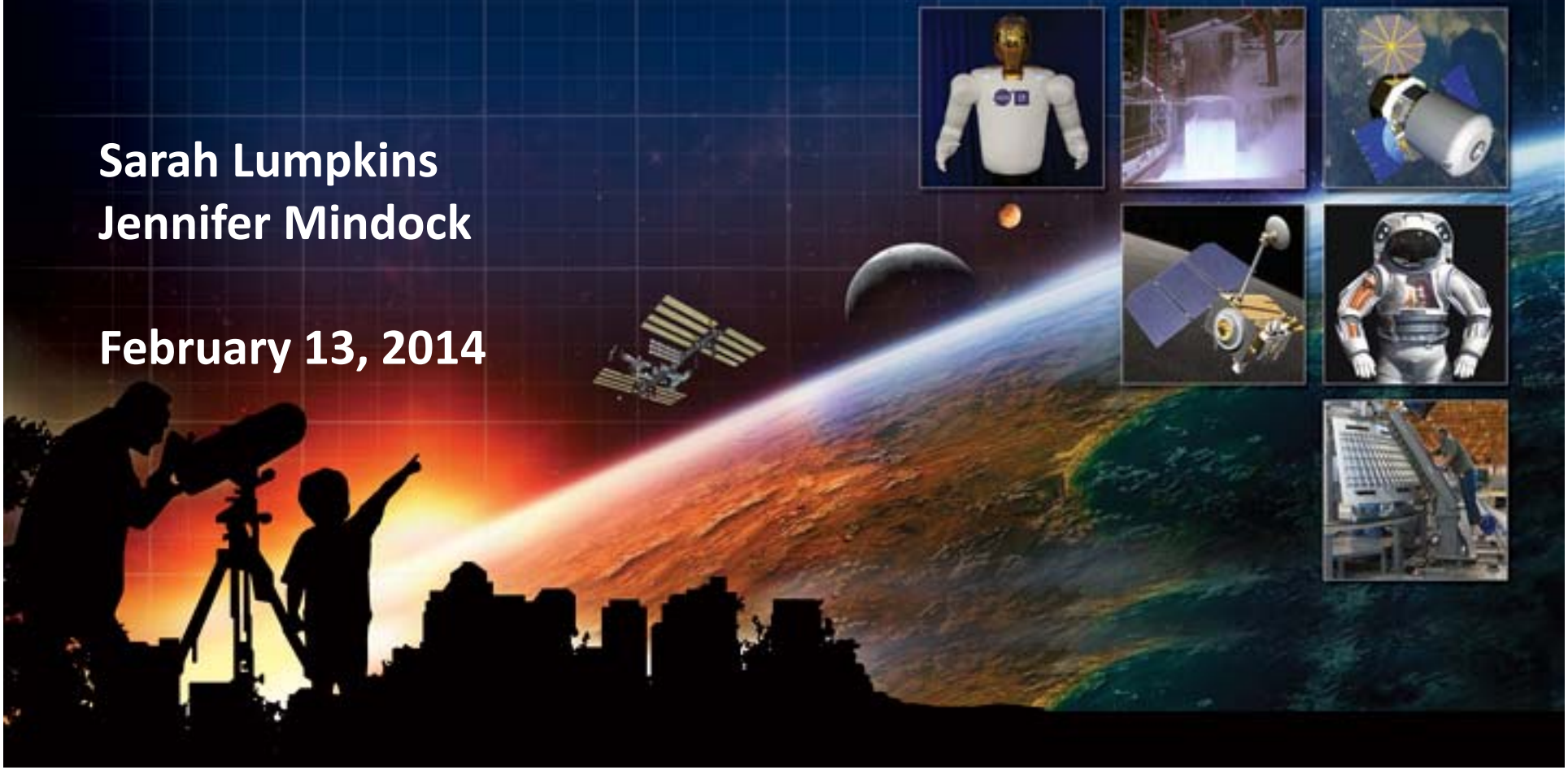
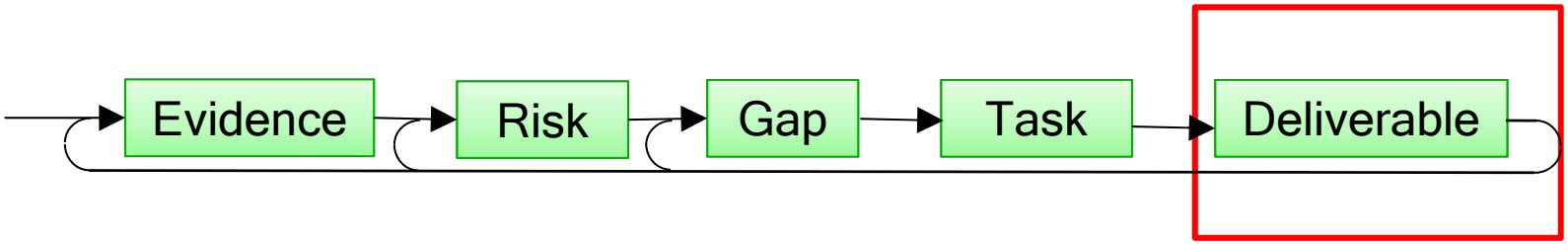
February 13, 2014



Purpose

- Provide an overview of the types of HRP deliverables
- Discuss how HRP deliverables contribute to the advancement of human space flight



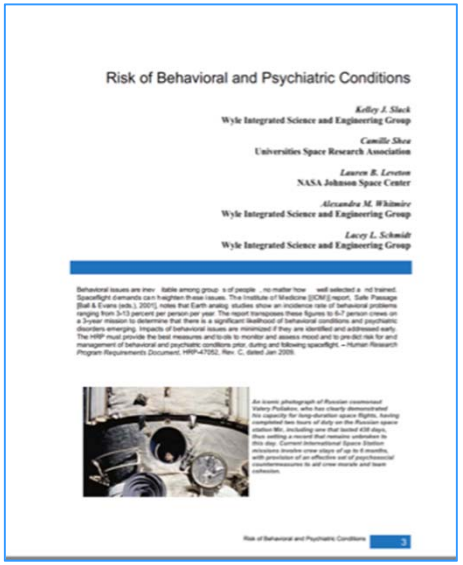
Types of Research Deliverables

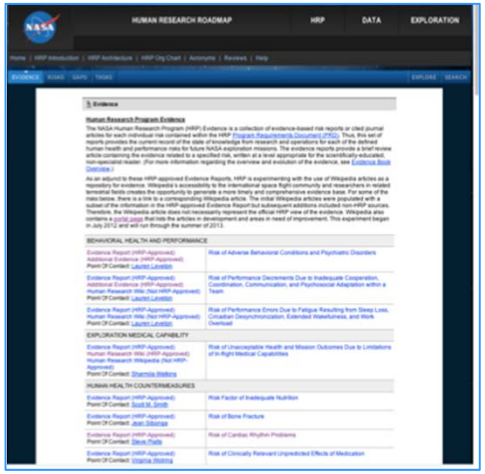
- Publications:
  - Build evidence base
  - Support risk characterization
  - Support research plan development

- Inform crew health and performance standards
- Develop technologies and countermeasures to meet the standards for crew health and performance
- Develop models

Evidence Base

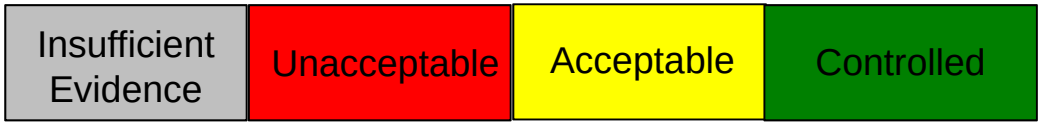
- Comprised of Evidence Reports, available on the HRP website: humanresearchroadmap.nasa.gov/Evidence
- Compilation of data from medical records, spaceflight operations, and research findings
- Provides record of the state of knowledge of each of the HRP risks
- Updated on an ongoing basis as new evidence emerges


Risk of Behavioral and Psychiatric Conditions



Risk Characterization

- Evidence base is evaluated to determine whether there is sufficient evidence:
  - to support the establishment of a new risk
  - to change the research rating of an existing risk



Research Ratings

Research Plan Development

- Evidence base is assessed to determine whether evidence and/or technology gaps exist
- Research plan is updated to ensure the most significant risks to astronauts are being adequately addressed
- The research plan also specifies which of the available research platforms are best suited for filling the knowledge gaps

Bedrest

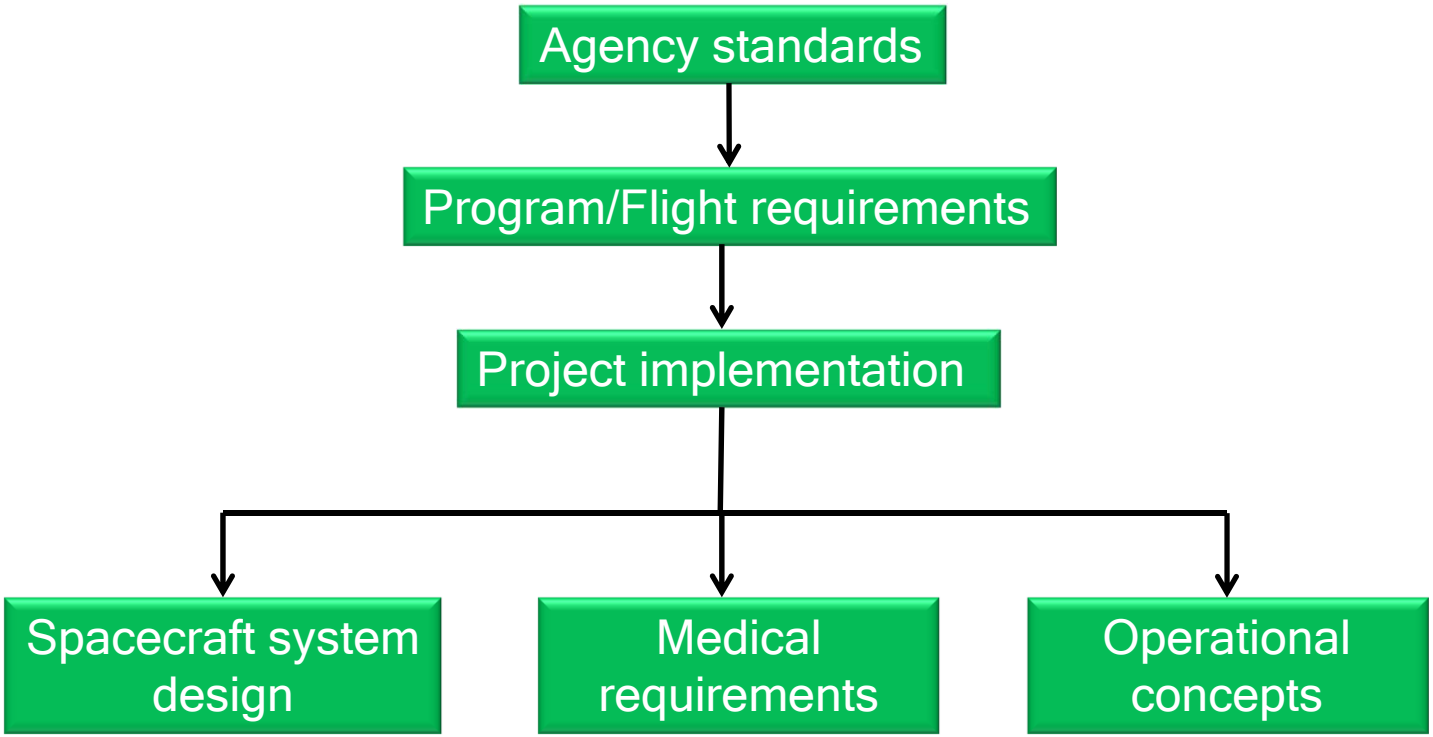
NASA Space Radiation Laboratory

Parabolic flight

NEEMO (underwater analogue)

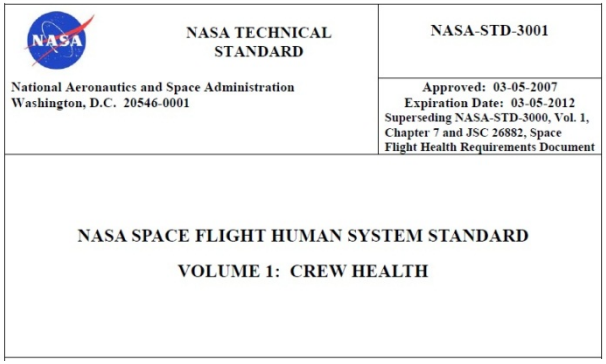
Standards

- Evidence also contributes to the development of standards



Standards

- Based on the best available clinical and scientific evidence, as well as experience from previous space flight missions
- Established to define acceptable levels of risk
- Reviewed as new evidence emerges
- Two volumes (NASA-STD-3001):
  - **Volume 1:** Crew health
    - Permissible exposure limits
    - Fitness-for-duty criteria
    - Permissible outcome limits
  - **Volume 2:** Human Factors, Habitability, & Environmental Health
    - Defines spacecraft standards
    - Focuses on human physical and cognitive capabilities and limitations



NASA TECHNICAL STANDARD

NASA-STD-3001

National Aeronautics and Space Administration
Washington, D.C. 20546-0001

Approved: 03-05-2007
Expiration Date: 03-05-2012
Superseding NASA-STD-3000, Vol. 1, Chapter 7 and JSC 26882, Space Flight Health Requirements Document

NASA SPACE FLIGHT HUMAN SYSTEM STANDARD

VOLUME 1: CREW HEALTH

Standards: Examples

Table 11 – Micronutrient Guidelines for Space Flight

Vitamin or Mineral	Daily Dietary Intake*
Vitamin A	700–900 µg
Vitamin D	25 µg
Vitamin K	Women: 90 µg
	Men: 120 µg
Vitamin E	15 mg
Vitamin C	90 mg
Vitamin B_{12}	2.4 µg
Vitamin B_6	1.7 mg
Thiamin	Women: 1.1 µmol
	Men: 1.2 µmol
Riboflavin	1.3 mg
Folate	400 µg
Niacin	16 mg niacin equivalents
Biotin	30 µg
Pantothenic acid	30 mg
Calcium	1200–2000 mg
Phosphorus	700 mg
	And ≤1.5 × calcium intake

Volume 2

Table 1 – 50th Percentile Values for Maximal Aerobic Power (ml $kg^{-1}min^{-1}$)

Age	Men	Women
20-29	43.5	35.2
30-39	41.0	33.8
40-49	38.1	30.9
50-59	35.2	28.2
60+	31.8	25.8

Volume 1

Table 1 – Average Relative Humidity

Average RH	Time Allowed
RH ≤ 5%	1 hr
5% < RH ≤ 15%	2 hr
15% < RH ≤ 25%	4 hr
25% < RH ≤ 75% (nominal range[1])	Indefinite[2]
75% < RH ≤ 85%	24 hr[3]
85% < RH ≤ 95%	12 hr[3]
95% < RH	8 hr[3]

Volume 2

Technologies/Countermeasures

- Meet medical and environmental standards
- Meet human system resource constraints (e.g., mass, volume, power, data)
- Ensure effective human system integration across exploration mission systems

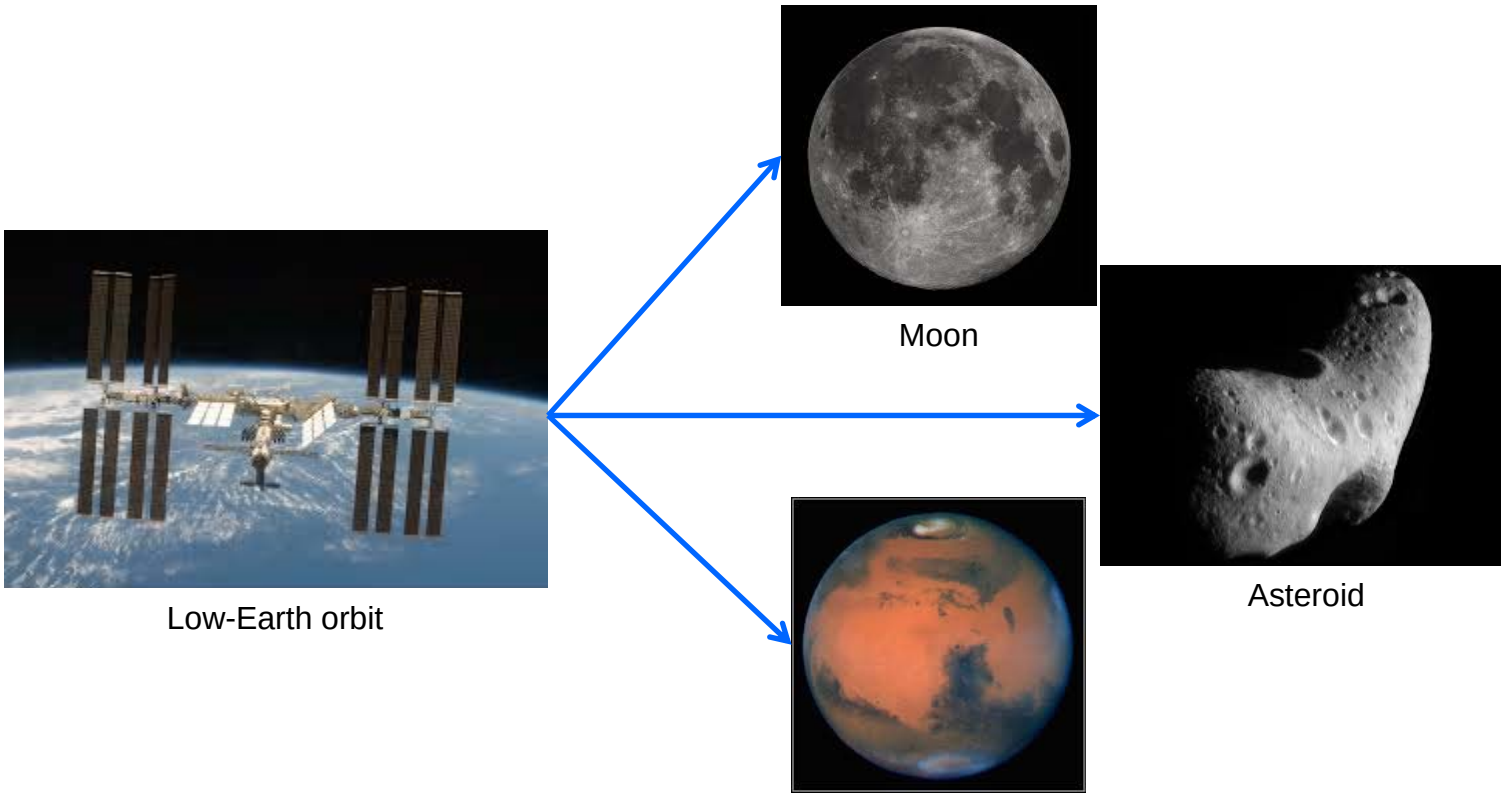
Orthostatic intolerance: compression garments and fluid loading

Space radiation: polyethylene shielding in sleeping quarters

Bone and muscle: Advanced Resistive Exercise Device

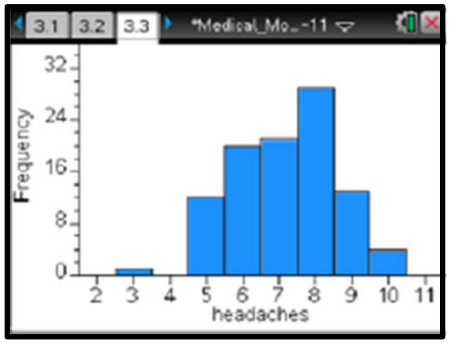
Technologies/Countermeasures

- Technologies and countermeasures should be developed for both current and future mission architectures

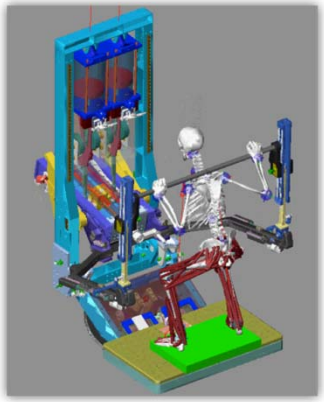


Models

- Deliverables can include stand-alone models or input to existing or future models
- Model examples:
  - Integrated Medical Model (IMM): designed to quantify the probability of the medical risks and potential consequences that astronauts could experience during a mission
  - Digital Astronaut: utilizes simulations of physiological function to answer targeted questions about changes associated with the microgravity environment



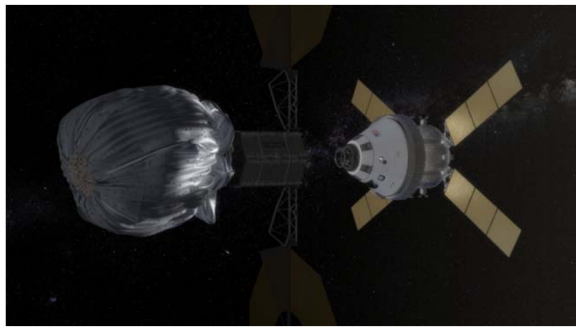
Sample IMM output

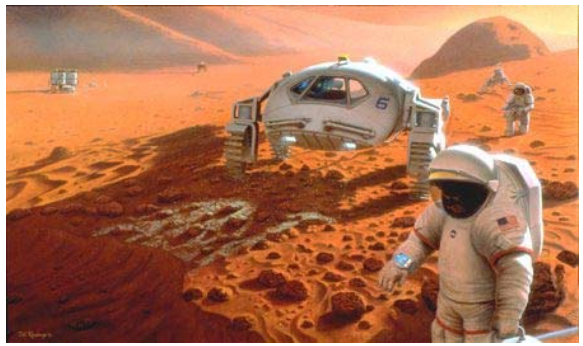


Quantification of muscle force & joint torque produced by ARED

Summary

- The utility of HRP research results extends far beyond publications
- Results contribute to a variety of deliverables supporting risk mitigation and the advancement of human space exploration beyond low-Earth orbit:
  - Evidence Base
  - Risk characterization
  - Research plan development
  - Standards
  - Technologies/countermeasures
  - Models





Questions?

- Feel free to contact me with any questions regarding deliverables or if you have a specific deliverable you want to bring to the attention of HRP personnel

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